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ESTIMATION OF POTENTIAL FROST RESISTANCE LEVEL OF SOME WOODY SPECIES FROM *Rosaceae* Juss. FAMILY

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The results of complex analyze of ice-forming processes in tissues of annual shoots of 11 species from 6 genera of *Rosaceae* Juss. family in connection with their potential frost resistance are shown. The range of tissues damage under -10, -20 and -30 °C temperatures influence was set by the method of direct freezing. By dint of the differential thermal analyze the features of running of ice-forming processes and ice migration in the different tissues of annual shoots of studied plants were found. Peculiarities of histological structure of annual shoots of these plants were investigated by the fluorescent microscopy method. As a results of conducted analyze the high level of potential frost resistance was diagnosed for plants from *Exochorda* Lindl., *Photinia* Lindl., *Prinsepia* Royle. genera, and susceptibility to freezing or drying winter shoots was revealed for plants from Kerria DC. *Rhodotypus* Sieb. et Zucc., *Stephanandra* Sieb. et Zucc. genera.

Introduction. Winter hardiness of woody plants is one of the main biological characteristics that define the mechanisms of plant adaptation to new conditions in the introduction. Determining component of introducents' winter resistance is frost resistance, as well as even short-term effect of severe frosts can cause serious damage or total loss of plants. The degree of frost resistance is closely associated with changes in water status and process of ice formation in woody plant tissues [2]. This feature determines the level of frost heterogeneous damages of plants in winter, mainly caused by the mechanical action of ice that forms in the cells and protoplasts breaks or migration front ice formation in the intercellular spaces, sucking action of which causes water out of the cells and thus their damage as a result of dehydration (so-called "winter drying" shoots) [3]. Therefore, determination of potential frost resistance is a key initial stages of introduction trials of woody plants.

Materials and methods. The object of the study were 11 species of tree Asian introducents from *Rosaceae* Juss. family, namely: *Exochorda giraldii* Hesse, *E. racemosa* (Lindl.) Rehd., *E. korolkovii* Lav., *E. tianschanica* Gontsch., *E. ×macrantha* (Lemoine) Schneid., *Kerria japonica* (L.) DC., *Photinia villosa* DC., *Prinsepia sinensis* (Oliv.) Kom., *Rhodotypus kerrioides* Sieb. et Zucc., S*tephanandra incisa* (Thunb.) Zbl., та *S. tanakae* Franch. et Sav. The potential frost resistance of plants determined during deep calm period (the second decade of January) by the method of direct freezing annual their shoots with subsequent analysis of tissue damage using microscopic anatomical and histological studies, differential thermal analysis and fluorescent microscopy. The results of evaluation of potential frost resistance compared with the data field (actual) winter hardiness, which was assessed by 8-point scale [11].

Direct freezing of shoots carried out by the standard in plant introduction method [12] during the deep calm period of plants in the second week of January. To study chose 3 shoots with a typical annual growth of the middle part of the krone. Shoots were frozen in the laboratory sector physiology of fruit plants of Horticulture Institute of NAAS of Ukraine in the refrigerator for research CRO / 400/40 at temperatures – 25 and 30 °C. Control plants were kept under natural conditions. Lowering the temperature of environment under freezing was performed at 5 °C/h. After reaching the desired temperature test samples were kept in this state for 6 hours and thawed at a speed of temperature increase of 5–6 °C/h. Regime of freezing monitored by 9 specially designed sensors thermal resistance, which was connected to an electric thermometer Щ – 455 [4].

Before the anatomical analysis of tissue damage plant samples were stored for 2–3 weeks in a cold room in closed plastic bags. Transverse sections of shoots produced using microtome and placed on slides in glycerol, collected by one cross-section of the upper and middle part of the shoot through the interstices and one longitudinal section through bud and then examined these samples under a microscope МБС - 10. The changes in color of tissues after freezing, the levels of damage of the bark, cambium, wood and core of shoots were determined.

The degree of tissue damage was assessed by a 6–point scale:

0 – no damage (0%);

1 – slight change in color, up to 20% damaged tissue;

2 – average tissue damage (40%);

3 – severe tissue damage clearly observed tissue browning boundaries with others (60%);

4 – very severe tissue damage: it's all faded, borders with other fabrics black (80%);

5 – total loss of tissue, which in some cases cannot be separated from the rest (100%).

Statistical analysis of the results of research conducted by the coefficients method [4]. For cambium, as the most important reparation tissue, ratio was 8, for bark – 6, wood – 4 and for core – 2. The amount of empirical coefficients equals to 20, under conditions of multiplying with the higher point of the individual tissue damage (5,0) equals to 100. Thus, it can be considered the hundred-percent destruction of the sample when the presence of complete tissue damage, minor degree of damage which is evident by the coefficient of less than 10, the average – from 10 to 40 strong – from 40 to 75 and very strong – more than 75.

The nature of the process of ice formation in annual shoots of plants defined by modified method of differential thermal analysis [5; 9] using specially created for the DTA device. The device temperature sensors served three chromel-copel thermocouple 0,3 mm in diameter covered with a special isolation. One thermocouple was injected into the core of shoot to a depth of 10–12 mm, the other – in comparison sample.

As indifferent standard paraffin was used with dimensions that are close to the size of the sample. Paraffin chosen because its heat capacity and thermal conductivity close to that of the samples. Thermocouples included poles towards each other. The signal provided to the input "Y" of highly sensitive two-coordinate potentiometer H - 307 with high input impedance. The third thermocouple was used for measure the temperature of the cooling chamber. The signal from the thermocouple provided to the input "X" of the same potentiometer. Due to the rather large thermoelectric driving power of chromel-copel thermocouple (up to 0,038 mV/°C) and high sensitivity of potentiometer, there was no need for intermediate amplification.

To analyze of ice formation used parts of shoots 3 cm length, 3,0–4,5 mm in diameter and 460–500 mg weight with a bark. During the research, samples cooled in two-stage type semiconductor micro refrigerator ТЛМ – 2. The temperature in the chamber was reduced at a constant rate of 1 °C/h in the range of +10 ...-40 °C. This connection allows thermocouple to measure reliably of the temperature difference between the sample and standard in the process of ice formation after short-term cooling.

At the same time an anatomical structure of tissues of annual shoots of Asian introducents due to their potential frost was established. Well-formed and stiffened annual shoots of the middle part of the krone were chosen as examples. Sections were carried out at the top of the shoots. Preparations examined under fluorescent microscope "ЛЮМАМ - И4" with 5?10 zoom. Living tissue lighted red and dead lighted green, moreover pigmented cell walls lighted yellow-green, bright yellow color acquired tissue with a high content of flavonoids and anthraquinone which causing yellow luminescence.

The field (actual) winter hardiness of Asian woody introducents was determined by an 8-point scale [11]:

1 – winter-hardy plant (wintered without damage);

2 – damaged ends of annual shoots;

3 – annual shoots damaged fully;

4 – damaged 2-year shoots;

5 – damaged 3-year shoots;

6 – damaged shoots to the level of snow cover;

7 – damaged shoots to root collar;

8 – the plant was killed by frost.

Results of investigations. The study of anatomical slices of frozen by the method [12] shoots of Asian shrubby introducents of Rosaceae family has shown that the most sensitive to the action of negative temperatures are the tips of shoots and buds. Middle of shoots damaged considerably less (Table 1).

Control variant of experimental plants in natural conditions in which daytime temperatures within Kyiv in the second decade of January did not drop below -10 °C, showed that some samples are damaged more than other. Thus, the low level of damage was indicated in species *E. racemosa, E. korolkovii, E. tianschanica, E. ×macrantha, E. giraldii, R. kerrioides, K. japonica* and *P. villosa*, which coefficient of damage ranged from 10,2 to 16,1 points. In plants *P. sinensis* (control) suffered shoot tips and buds, but only the middle part of shoots was slightly damaged. Most intensive damage shoots was found in the plants from genus Stephanandra – its rate has not fallen below average even for their middle parts, and the rate of damage of tops in *S. incisa* in control was 22,4 points (Fig. 1).

In the variant with freezing temperature -25 °C coefficient of tissue damage of shoots compared with the control significantly increased (Table 1). Most intensive tissue damage suffered shoot tips of *E. racemosa, P. villosa, S. incisa* and *S. tanakae* (40,4–62,2 points). Much less in this variant of freezing hit the middle part of shoots (11,2 – 18,4 points), but in *P. villosa* its value reached average (38,4 points). In the genus Stephanandra coefficient of damage of this zone were also average (22,2 points in *S. incisa* and 30,8 in *S. tanakae*). A higher rate of

Table 1. Damage of annual shoots of Asian woody introducents from *Rosaceae* family after direct freezing and the points of their winter hardiness by S.Y. Sokolov's scale

Species	Variant	Coefficient of damage plant parts, points				Average point of winter hardiness
		Top of shoot	Middle of shoot	Bud	The total coefficient of damage	
Exochorda giraldii	Control	8,2	7,2	11,0	26,4	1,0
	–25 °C	19,4	11,8	12,8	44,0	
	–30 °C	**40,6**	**21,6**	**20,4**	**82,6**	
E. korolkovii	Control	7,0	3,2	5,6	15,8	1,0
	–25 °C	27,8	13,2	13,0	54,0	
	–30 °C	**73,2**	**25,6**	**43,8**	**142,6**	
E. racemosa	Control	7,0	5,0	3,5	16,5	1,0
	–25 °C	40,4	12,6	16,0	69,0	
	–30 °C	**59,2**	**26,8**	**31,2**	**117,2**	
E. tianschanica	Control	6,0	5,2	6,2	17,4	1,0
	–25 °C	24,4	13,8	14,8	53,0	
	–30 °C	**52,2**	**21,6**	**35,0**	**108,8**	
E. macrantha	Control	5,0	8,4	9,0	22,4	1,0
	–25 °C	20,6	11,2	12,2	44,0	
	–30 °C	**52,4**	**42,6**	**27,6**	**122,6**	
Kerria japonica	Control	4,8	7,6	16,1	28,5	2,7
	–25 °C	24,8	14,6	16,0	55,4	
	–30 °C	**43,2**	**16,6**	**23,6**	**83,4**	
Photinia villosa	Control	6,6	8,2	10,2	25,0	1,0
	–25 °C	62,2	38,4	43,0	143,6	
	–30 °C	**36,0**	**22,4**	**25,4**	**83,8**	
Prinsepia sinensis	Control	9,4	11,6	12,8	33,8	1,0
	–25 °C	23,0	16,0	16,0	55,0	
	–30 °C	**25,6**	**15,8**	**19,6**	**61,0**	
Rhodotypus kerrioides	Control	6,8	6,4	5,4	18,6	2,3
	–25 °C	17,2	14,2	18,2	49,6	
	–30 °C	**24,4**	**24,4**	**24,8**	**73,6**	
Stephanandra incisa	Control	22,4	20,6	13,0	56,0	2,3
	–25 °C	40,4	22,2	23,4	86,0	
	–30 °C	**58,2**	**23,2**	**31,8**	**113,2**	
S. tanakae	Control	17,0	11,4	11,8	40,2	2,0
	–25 °C	41,2	30,8	34,2	106,2	
	–30 °C	**58,2**	**48,4**	**35,8**	**142,4**	

buds injury after their freezing under the temperatures -25 °C was in *P. villosa* (43 points). Also much suffered the buds of *S. incisa* and *S. tanakae* in comparison with other plants (damage average – 24,3–34,2 points).

By freezing shoots of woody plant species under the temperatures -30 ˚C detected the enhancing of tissue injury. Only damage of *P. villosa* in comparison with previous variant of the experiment was less significant (Table 1). In this variant, the hardest hit of shoot tips indicated for species *E. racemosa, E. korolkovii, S. incisa, S. tanakae* (Fig. 2), *E. tianschanica* and *E. ×macrantha* (52,2–73,2 points) that confirmed the high levels of damage. In other plants coefficient of damage equaled or was slightly higher than the average (from 24,4 to 43,2 points). Buds after freezing under the temperatures -30 ˚C suffered less than shoot tips, and damage rates did not exceed the average. Middle parts of shoots proved the most stable in P. sinensis and *K. japonica* (15,2–16,6 points). Substantial damage of the middle parts of the shoots in this variant of the experiment has been determined for *S. tanakae* and *E. ×macrantha* (48,4 and 42,6 points respectively).

The total damage point of plants shoots was the highest in the third variant of the experiment after freezing shoots under the temperatures -30 ˚C. Only for *P. villosa* in the second variant of the experiment this index exceeded the same in the third one (143,6 vs 83,8 points). The most significant impact of such temperature affected shoots of *E. korolkovii* (142,6 points), *S. tanakae* (142,4), *E. ×macrantha* (122,6), *E. racemosa* (117,2), *S. incisa* (113 2) and *E. tianschanica* (108,8 points).

The most vitally important part of wintering plants is bud and the rate of its damage and the same of the middle part of the shoot was the determining for assessing the level of frost resistance. By the method of microscopic studies of cross sections of shoots of woody introducents from Rosacaea family has been found that due to the influence of low temperatures the most damaged tissue is in core, bark and wood, the least - in cambium. So the least frost resistanse tissues should be considered bark, wood and core, but cambium – the most resistant to the action of frost. This is extremely important because cambium, as generating tissue, is the most necessary component in the life of woody species, to support growth and regeneration.

Direct freezing showed the potential susceptibility to frost damage of annual shoots in the genus Stephanandra, because in research variants and in control high rates of coefficient of tissue damage were observed for these plants. Also shoot tips of the most plants from Exochorda genus are greatly affected after freezing under the temperatures -30 ˚C (*E. tianschanica* (52,2 points), *E. ×macrantha* (52,4) *E. racemosa*

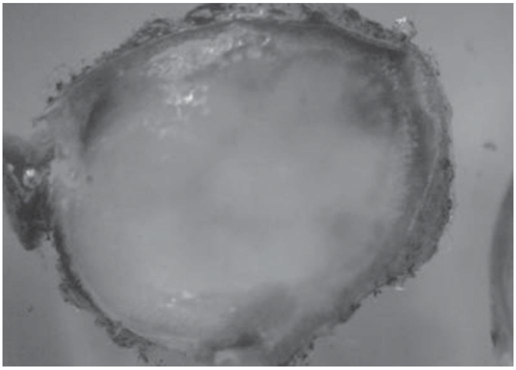

Fig. 1. Tissue damage of annual shoot top of *Stephanandra incisa* in control (zoom 4×10)

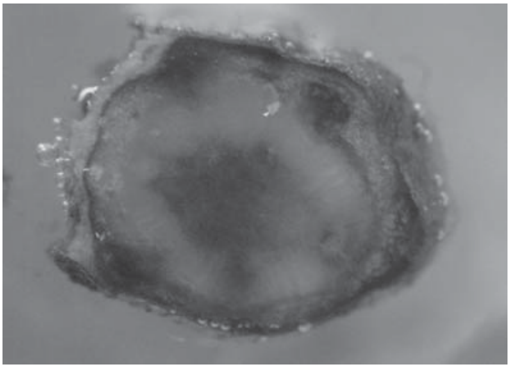

Fig. 2. Tissue damage of annual shoot top of *Stephanandra tanakae* after its direct freezing under the temperatures –30 ˚C (zoom 4×10)

(59,2) and *E. korolkovii* (73,2 points)).

In order to set the running of ice formation in tissues of annual shoots of woody plants we used the method of differential thermal analysis (DTA) [14], which based on the analysis of thermograms of ice formation with taking into account the value of individual bands and the intervals of their appearance [7; 13]. The method is grounded on the fact that the transformation of water into ice is a process that accompanied by latent heat, which is recorded on a thermograms as difference of signals from thermocouples, resulting from an increase in temperature of the sample compared to anhydrous standard. Temperature changes of the sample during the crystallization of water appear as separate peaks of heat on it thermograms. Ice formation in various tissues of sample is uneven, so on the thermograms appear several peaks (ekzotherms), amplitude and position of which are largely determined by the physical and water properties of tissues. In high frost resistant plants appear only one high temperature ekzotherm (HTE), the occurrence of which is observed in the freezer temperature -5...-10 °C. In plants with limited frost resistance at low temperatures appear sharp peaks associated with damage and death of tissue caused by intracellular freezing (low ekzotherm (LTE)) [6]. More frost resistible considerate the plants which have the initiation of ice formation and HTE at higher temperatures, but LTE at the same time appears in the tissues of these plants at lower temperatures, what causing an increasing of interval between the peaks of HTE and LTE on thermograms. Consequently, by the value of the interval between high- and low-temperature ekzotherms can assess the level of winter hardiness of woody plants.

Analysis of ice formation using thermographic method showed features of latent heat excretion in the tissues of woody plants shoots. In the spectra of heat excretion of samples sufficiently identified several distinct bands in the temperature range – 7...-30 °C. The first ekzotherm, which appears in the temperature from -8 to -15 °C (HTE) describes the process of ice formation in xylem tissues, the second one (TE), recorded at -15...-25 °C – in phloem tissues [15]. Relatively low temperature of ice formation initiation in the phloem explains by the small size of cells and the presence of a significant amount of dissolved natural cryoprotectants in the intercellular space [7]. In the range of heat excretion of phloem (-20...-35 °C) we recorded a few low-temperature ekzotherm (LTE) associated with freezing water in the xylem micro capillaries.

Analysis of thermograms showed that potentially more frost hardiness plants can be considered the species rom genus Exochorda (Fig. 3) and R. kerrioides, which have got the widest range of temperature while ice formation [1].

According to the index HTE/LTE of ice formation in micro- and macro capillaries of xylem in woody plants from *Rosaceae* family has been found that the highest adaptive adjustments to low temperatures characteristic to *E. tianschanica, E. korolkovii, E. racemosa, P. sinensis* and *R. kerrioides*, where it ranged from 0,3 to 1,0. For the rest of the plants was characteristic advantage of temperature maximum of ice formation in xylem micro capillaries what confirming their potential susceptibility to frost damage [1].

For estimating the frost resistance was proposed to use the ratio of the amplitudes of the maxima exothermic processes in xylem and phloem on a scale [7]. In particular, the ratio of frost resistant species ratio phloem and xylem ekzothermal maximums is less than 1,0, middle frost resistant – 1,2–1,5, low frost resistant – more than 1,5 [7]. This dependence which was found by previous researchers has been confirmed in our investigations [6].

Based on the ratio of HTE/TE we found that this indicator only one *R. kerrioides* had amplitude of ice formation in xylem greater than the phloem (the ratio of HTE/TE>1 and ranges from 1,25 to 3,2). In other introducents dominated phloem maximum, but it didn't confirm the susceptibility of plants to low temperatures lesions as intense loss of water in phloem tissues, which is inherent to *R. kerrioides*, could prove their desiccation and death.

Adaptation to influence of low temperatures, such as hardening process or acclimatization, accompanied by loss of water in phloem and xylem cells. Large vessels of xylem have higher probability to ice formation, especially in the intercellular spaces, which causing extra water out of the cells by osmotic gradient that causes drying and reduces the risk of ice formation in the cell. Therefore, a mechanism of adaptation to low temperatures is early initiation of ice formation and high enough velocity of outflow of water at the center of ice formation in the intercellular spaces. Ice formation in the intercellular spaces and large vessels accompanied by heat excretion, which is recorded as high ekzotherm. The emergence of low-ekzotherm explained by the ice formation in micro capillaries of xylem. Small size of micro capillaries causes high potential of water vapor, thus significantly decreasing the temperature of ice formation. In addition, in small vessels present cryoprotectants (sugar, low protein, etc.) those also reduce performance of LTE. In micro capillaries pools of water is concentrated that maintains the optimum level of water balance of plants, especially during drought. However, high capacity of water holding causes a risk of tissue damage under conditions of hypothermia to critically low temperatures. The interpretation of low ekzotherm as the ekzotherm of plants' death occurred in literature sources [13], but some authors believe that in some cases plants' death occurs under different temperatures [9]. The high amplitude of low ekzotherm evidences about a significant accumulation of supercooled water and about the high risk of damage of micro capillaries during ice formation. Therefore, we believe that the ratio LTE to HTE is sufficient objective indicator of risk of low temperature damage during freezing supercooled water, and for plants with higher adaptive capacity, this index will be in favor of HTE.

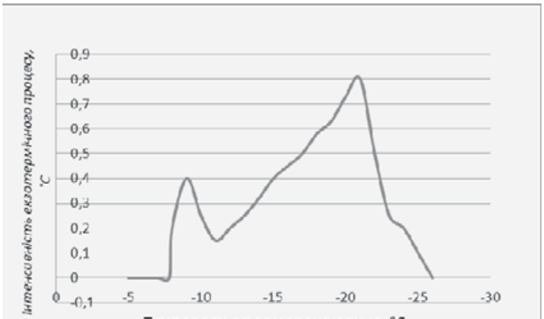

Fig. 3. Ekzotherms of ice formation in tissues of annual shoots of *Exochorda giraldii*

These results of study of the nature of ice formation in the tissues of Asian woody plants from Rosaceae family confirmed a potential susceptibility to damage of species from genus Stephanandra which was established by the method of direct freezing annual shoots. Incidentally, these results also showed a rather high adaptive capacity in plants *P. sinensis*, *E. tianschanica*, *E. korolkovii* and *E. racemosa*, which showed a tendency to damage. Also was found that the nature of ice formation can lead to tissue damage in annual shoots of K. japonica.

Comparing data from studies of potential frost resistance of Asian woody introducents with actual index of visual assessment scale of their damage in winter (Table 1) found that species of Exochorda proved resilient, confirming the results of DTA. Detected in the experiment with direct freezing

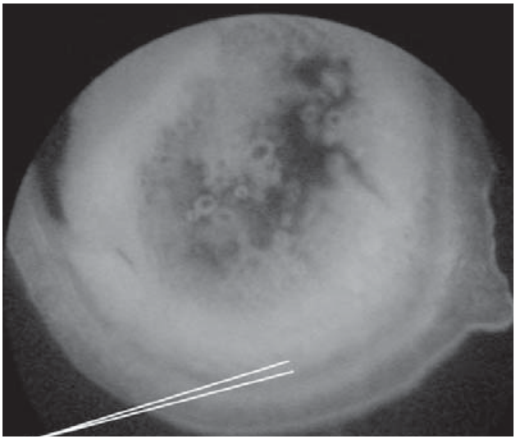

Fig. 4. A layer of wood on the cross–section of annual shoots of *Kerria japonica* in the bright of fluorescent microscope (zoom 5×10)

shoots susceptibility to damage under temperatures -30 °C of these plants but not confirmed by field data, associated perhaps with changes in the composition of cryoprotectants in their tissues, due to the transfer of the cold cut shoots in the laboratory and then gradual re-freezing. In plants of Exochorda by fluorescence microscopy revealed thick layer of wood, but according to some authors [2], the level of frost is closely linked to changes in the state of water in this tissue. Optimally developed wood, because of the large number of micro capillaries is able to retain moisture in the winter due to high water absorption [8]. When the xylem vessels formed by a small number of capillaries, it may be one of reasons for the high loss of moisture in the winter and damage the shoots by the "winter drying" type. The risk of damage is enhanced because the main function of the thin timber is reinforcing, and large part of the vessels develops thick cell wall permeated with lignin, what limit the internal cavity of vessels and reduces the amount of water that is able to stock up on wood.

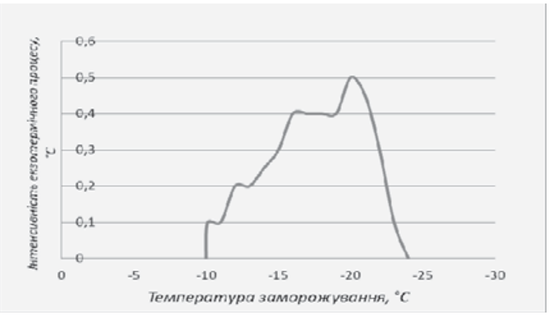

Fig. 5. Ekzotherms of ice formation in tissues of annual shoots of *Photinia villosa*

The results of field observations of winter hardiness of K. japonica show that these plants are damaged during winter conditions in Kyiv. At the tips of annual shoots of K. japonica after winter noticeable the area with necrosis, and after harsh winters, as in 2010, when temperatures reached -35 °C, shoots may die back to the level of snow cover, and plants lose 70% phytomass. Direct freezing revealed no significant damage tissues shoots of *K. japonica.* DTA results confirmed the potential susceptibility of plants to damage. Obviously, *K. japonica* tissue damage caused not only by low temperatures, but also a set of factors, which include winter drying. These changes confirmed by anatomical studies. In annual shoots of *K. japonica* revealed a thin layer of wood (Fig. 4), which causes dehydration of cells due to water migration toward front of ice formation in the intercellular spaces due to lack of quantity of micro capillaries in xylem, which is confined to the water and prevent the occurrence of water deficit.

Annual shoots of *P. villosa* and *P. sinensis* distinguished of high levels of winter hardiness potential, which is confirmed by the actual data field observations (Table. 1). Results for anatomical studies of frozen annual shoots of these plants under temperature -25 and -30 °C have shown that tissue damage is less than average. According to the data obtained from DTA, temperature range of HTE ice formation in P. villosa is narrow (Fig. 5), and this ensures potential resistance to winter drying of its shoots.

In *R. kerrioides* we observed a significant

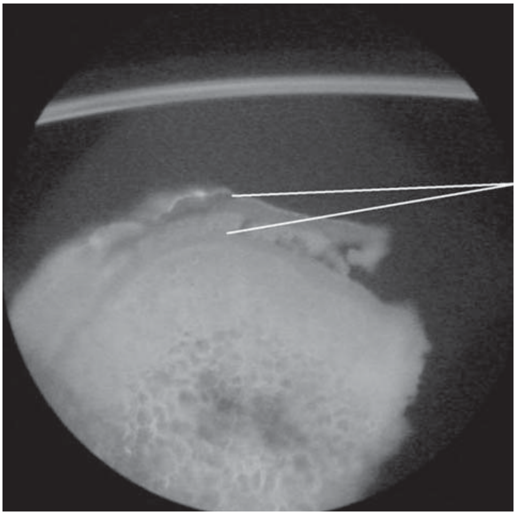

Fig. 6. Periderm on the cross-section of annual shoots of *Stephanandra* in the bright of fluorescent microscope (zoom 5×10)

loss of water in the phloem, which resulted in low amplitude and considerable supercooling up to -19...-21 °C. High ratio of HTE/TE of this plant caused by the intense of water loss in core tissue and by the decrease of the TE amplitude. Drying took place also in xylem cells, which increased xylem tissue resistance to migration of ice front formation and increased of temperature range of exothermic processes shoots. Thus, a set of indicators, which reflects relatively high adaptive potential of this species, is formed. Such adjustment is determined by the risk of drying shoots under long cold conditions, accompanied by winds during overwintering. Noticed significant dying of R. kerrioides shoots above snow cover (Table 1) may have been caused by "winter drying" damage type.

The experimental results revealed the potential susceptibility of the genus Stephanandra to lesions in the winter period. The actual winter hardiness of these plants confirmed the prognostic data – *S. incisa injury* score was 2,3, and S. tanakae – 2,0 (Table 1). Anatomical studies of their annual shoots revealed the presence of thin periderm (Fig. 6). It is noted that winter hardiness of shrubby plants directly proportional to the number of periderm layers [6]. Periderm – a secondary coating tissue that formed as a result of activity of secondary lateral meristem – phellogen or cork cambium [10]. Underdeveloped periderm with a large number of lenticels per unit of leaf area contributes winter desiccation [6]. It is obvious that low-power periderm of Stephanandra's annual shoots causes their susceptibility to damage during the winter.

Conclusions

Potentially frost resistant plants are *Exochorda*, *Photinia* and *Prinsepia*. Resistance plants from Exochorda genus confirmed by differential thermal analysis and the features of the anatomical structure their annual shoots. These peculiarities provide such processes of ice formation in their shoots which prevent mechanical damage protoplasts and do not lead to dehydration of tissues. *Resistance* of *Photinia* villosa to effects of low temperatures confirms results of direct freezing. The average coefficient of tissue damage annual shoots, after freezing under temperature -30 °C is to shoot tips – 36,0, to shoot middle – 22,4 and to buds – 25,4. Prinsepia sinensis showed resistance to damage by low temperatures under conditions of direct freezing. Potentially susceptible to damage during winter are the genera *Kerria*, *Rhodotypus* and *Stephanandra*. Because of the thin layer of wood in annual shoots of *Kerria japonica*, front of ice formation, which occurs in the intercellular spaces, causes the appearance of water deficit. In *R. kerrioides* high correlation VTE/TE was observed, it is caused by intense water loss of core tissues. As result, occurs a risk of drying shoots under conditions of long-term cold, accompanied by winds. The potential susceptibility to damage during winter plants of *Stephanandra* detects thin periderm in their annual shoots.

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АННОТАЦИЯ

Бабицкий А.И., Китаев О.И., Трофименко Н.М., Григорюк И.П. *Оценка уровня потенциальной морозоустойчивости некоторых видов древесных растений семейства Rosaceae Juss. // Биоресурсы и природопользование. – 2014. –* ***6****, № 3–4. – С. 151–160.*

Представлены результаты системного анализа процессов образования льда в тканях однолетних побегов 11 видов растений из 6 родов семейства Rosaceae Juss. в связи с их потенциальной морозоустойчивостью. Установлена степень повреждения тканей низкими температурами -10, -20 и -30 °C. Определены особенности функционирования процессов льдообразования и миграции его фронта в тканях однолетних побегов растений.

АНОТАЦІЯ

Бабицький А.І., Китаєв О.І., Трофименко Н.М., Григорюк І.П. *Оцінка рівня потенційної морозостійкості окремих деревних видів рослин родини Rosaceae Juss// Біоресурси і природокористування. – 2014. –* ***6****, № 3–4. – Р. 151–160.*

У статті наведено результати системного аналізу процесів утворення льоду в тканинах однорічних пагонів 11 видів рослин з 6 родів родини Rosaceae Juss. у зв'язку з їхньою потенційною морозостійкістю. Методом прямого проморожування встановлено ступінь пошкодження тканин низькою температурою -10, -20 та -30 °C. За допомогою диференційного термічного аналізу визначено особливості функціонування процесів льодоутворення та міграції його фронту у тканинах однорічних пагонів рослин.